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CONDUCTING AND HEAT-INSULATING PAINTWORK MATERIALS BASED ON NICKEL-PLATED GLASS SPHERES

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It is established that nickel-plated hollow glass microspheres can be used as conducting and heat-insulating fillers for paintwork material serving as a basis for coatings with low resistivity and good heat-insulating properties.

One of the most important properties of conducting paintwork materials (PM) is their ability for conducting electric current, which makes it possible sometimes to use them instead of metals. Conducting fillers usually applied in PM are soot, graphite, technical carbon, as well as metal powders [1]. PMs based on metal powders have higher conductivity than, for instance, PMs with a carbon filler [2]. However, metal fillers have an essential disadvantage: their high sedimentation rate causes stratification of paint and a nonuniform distribution of the filler in the paint coat layer.

Therefore, metallized core pigments, i.e., particles of silica, mica, or inorganic fiber coated with a metal layer, are of obvious interest for the production of conducting paint materials. Core pigments have the following advantages over metal powders:

– they have no sedimentation in a polymer binder;

– they decrease the threshold concentration of filler under which the polymer binder acquires conducting properties;

– they are significantly less expensive than fillers made of precious metals.

Spherical hollow glass particles covered with a metal layer are of special interest as core pigments. Their industrial production has become possible as a consequence of advances in plasma technology and engineering [3]. Such core pigments have low volume density (0.1 – 0.3 g/cm^3), relatively high specific compressive strength (20 – 38 MPa), good adhesion to polymer binders, and good heat-insulating properties [4]. Therefore, metallized hollow microspheres can be successfully used not only as conducting PM fillers but as heat-insulating fillers as well.

The purpose of the present study is studying the possibility of application of metallized glass microspheres as conducting and heat-insulating PM fillers. To produce metallized core pigments, we used industrial hollow glass microspheres MS-VP-A9 dressed with γ-aminopropyl-triethoxysilane (TU 6-11-367–75). Glass spheres constitute easily friable powder consisting of spheroid glass particles of size 30 – 80 μm with wall thickness 0.5 – 2.0 μm. The volume density of glass spheres is equal to 0.16 – 0.21 g/cm^3.

Before nickel plating, glass spheres were sensitized in a tin chloride solution and then activated in 0.5% palladium chloride solution. The reduction of nickel was carried out at a temperature of 82 – 84°C and pH = 4.5 – 5.5 in a solution containing (g/liter): 6 nickel chloride, 8 sodium hypophosphite, 10 sodium acetate. To ensure the stability of the process, the solution was thermostatically controlled while stirring glass spheres. The level of pH was measured by a pH-340 meter with a glass electrode. Nickel plating lasted 40 min. The volume density of glass spheres after nickel plating was equal to 0.5 – 0.7 g/cm^3.

The x-ray phase analysis of samples was performed on a DRON-3 plant (CuK_α radiation, Ni filter). According to x-ray phase analysis, the coatings formed on the surface of glass spheres have only one phase: metallic nickel (Fig. 1).

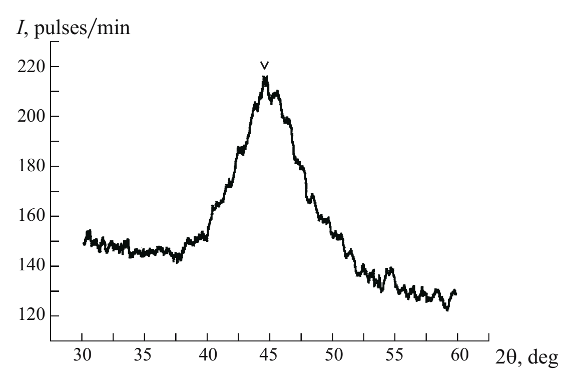

Fig. 1. X-ray pattern of nickel-plates glass spheres: v) metallic nickel.

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Liquid PM composites were prepared by mixing 5 – 30% (here and elsewhere wt.%) nickel-plated glass spheres with 70 – 95% polyacrylic lacquer AS-528. The composite was diluted to a viscosity of 80 – 100 sec using solvent R-5 according to GOST 8420–74. The composite was applied by casting on plastic, wooden, and cardboard samples of size 3 × 3 cm. The drying of the coating (GOST 19007–73) lasted 1 – 1.5 h. The compatibility of the composites with painted surfaces and the adhesion of coatings to substrates were determined according to GOST 29318–22 and GOST 15140, respectively.

The research indicates that the surface of metallized glass spheres is well wetted by the polymer binder. The obtained composites are compatible with surfaces that have to be painted and have good adhesion to these surfaces.

The resistivity of coatings was measured using a Shch-4300 combined instrument. The ratio between the quantity of binder and the conducting phase determines the resistivity of the coating (Table 1). It can be seen that the surface resistivity of the developed coating depends on the quantity of the conducting filler. Thus, an increase in the content of metallized glass spheres in a coating decreases its resistivity.

The thermal conductivity of the samples was determined according to GOST 7076–99. The obtained results are shown in Table 2.

It is known that a distinctive feature of heat-insulating materials is their high porosity, which significantly decreases their thermal conductivity. The optimum heat-insulating capacity is observed in materials with closed spheroid pores. Since air is the component with the lowest thermal conductivity in heat-insulating materials, their thermal conductivity to a large extent depends on the quantity of air inclusions.

Increasing the content of metallized hollow spheres in a paint or lacquer coating significantly decreases its thermal conductivity and, accordingly, improves the heat-insulating characteristics of the coating (Table 2).

TABLE 1

Sample	Component ratio, %		Surface resistivity, Ω/cm^2
	lacquer AL-528	nickel-plated glass spheres	
1	95	5	950
2	90	10	240
3	80	20	85
4	70	30	62

TABLE 2

Sample	Weight content, %		Thermal conductivity, W/(m · K)
	lacquer AL-528	nickel-plated glass spheres	
0	100	–	0.48
1	95	5	0.30
2	90	10	0.24
3	80	20	0.15
4	70	30	0.12

Thus, hollow nickel-plated glass microspheres can be used as conducting and heat-insulating fillers for paintwork materials, in order to produce coatings with low resistivity and good heat-insulating properties. Such paintwork materials can be used in radio engineering and electronics.

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